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COMPLETE SPECIFICATION

Improvements in or relating to Electrostatic Dust Precipitation

We, WESTINGHOUSE ELECTRIC INTERNATIONAL COMPANY, of 40, Wall Street, New York 5, State of New York, United States of America, a Corporation organised and existing under the Laws of the State of Delaware, in said United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

In electrostatic gas-purifying dust-precipitators of a type in which one electrode discharges toward a second electrode for producing charged matter of essentially one potential polarity in the space between the electrodes, an objectionable phenomenon known as "back-ionization" sometimes occurs which decreases the gas-cleaning efficiency of the dust-precipitator and increases its power consumption. Back-ionization is very likely to occur if the gas being cleaned is hot and dry as it passes the electrodes or if the foreign particulate matter it contains is of comparatively high electrical resistivity. The former condition is usually met with in the cleaning of industrial gases, such as, for example, flue gas from boilers burning powdered coal; and the latter condition is frequently found in the cleaning of air. Should back-ionisation occur in air-cleaning dust-precipitators of a type such as described in the Specification of Letters Patent No. 475,443, it could be a source of objectionable ozone, and could cause vibration and breaking of ionizing wires.

Various schemes have been proposed and used for minimizing back-ionisation and discouraging the probability of its occurring. One way for discouraging back-ionization is to treat the gases before they enter the electrostatic dust-precipitator, usually in order to control the resistivity of the precipitated particles or to control the temperature and humidity of the gas. For convenience reference will hereinafter be made to the particles electrostatically removable from a gas as dust or the like.

In most of the expedients hitherto used to discourage back-ionization it is necessary either to provide heat exchange equipment for extracting heat from the gas, or to introduce a liquid directly into the gas, or to expose the gas to contact with a foreign liquid. The use of heat exchange equipment may have the advantage of recovering some of the heat in hot gases, but the equipment usually becomes too bulky and expensive if it is to reduce the temperature of the gases to a point where a worthwhile gain is obtained in cleaning efficiency by reduction of back-ionization. The introduction of liquid into the gases is frequently objectionable because it increases the chances of corrosion of the equipment through which the gas passes, and also may increase the potency of the obnoxious chemical constituents of the gas. Additionally, from a practical viewpoint nozzles used to introduce the spray clog easily, destroying the fineness of the spray so that large drops result which do not completely evaporate.

The chief object of the present invention is to provide an improved simple and efficient means and method of electrically precipitating dust from hot, dry gases or from gases, such as atmospheric air, having dust particles of high electrical resistivity, in which back-ionization is discouraged.

A further object of the invention is to provide means and methods for electrically precipitating dust from gas, which substantially avoid back-ionization but without the use of large or expensive equipment, and without introducing foreign matter into the gas.

With the above objects in view, the

invention resides in a method of electrostatically precipitating dust or the like from a gas by passing the gas successively through an ionizing zone and a precipitating zone, wherein the ionizing zone is constituted by an electrostatic field established between spaced discharging and non-discharging electrodes, said non-discharging electrode or electrodes being hollow and cooled to a temperature below that of the gas under treatment, by a cooling fluid passing through said hollow electrode or electrodes and out of contact with the gas under treatment, thereby to prevent or minimize the occurrence of back ionization.

According to another aspect, the invention resides in electrostatic dust precipitation apparatus having an ionizing chamber and a precipitation chamber, said ionizing chamber comprising means for establishing an electrostatic field therein, including spaced discharging and non-discharging electrodes, said non-discharging electrode or electrodes being hollow and cooled to a temperature below that of the gas under treatment, by a cooling fluid passing through said hollow electrode or electrodes and out of contact with the gas under treatment, thereby to prevent or minimise the occurrence of back-ionization.

In order that the invention may be more clearly understood and readily carried into effect, reference will now be made to the accompanying drawings, in which:—

Fig. 1 is a partial horizontal sectional view through an equipment embodying the present invention;

Fig. 2 is a sectional view substantially along the lines II—II of Figure 1;

Fig. 3 is a view substantially along the lines III—III of Figure 1;

Fig. 4 is a simplified wiring diagram for energising the relatively insulated electrodes of a dust-precipitation means;

Fig. 5 is a view, similar to Fig. 2, of a modified form of invention;

Figure 6 is a curve showing a relationship of tube-temperature (abscissa) to total wire-current (ordinates) for indicating the effect, under certain operating conditions, of the temperature of a non-discharging electrode of the tube type on back-ionization;

Fig. 7 is a curve showing the maximum allowable tube-temperature (ordinates) in an equipment for cleaning air at various dew points (abscissæ) without back-ionization, and

Fig. 8 is a partial view of two abutting sides of two ionizing units of modified form, for an electrostatic dust-precipitator assembly.

In the drawing, there is shown equipment which is useful for electrically cleaning atmospheric air having heavy dust-concentrations, such equipment being of the two stage type along the lines as disclosed in the aforesaid Patent Specification No. 475,443. However, it is to be understood that this invention is not necessarily limited to dust-precipitators of this particular type, described in the aforesaid Patent Specification, nor is it limited to the cleaning of atmospheric air.

Referring to the drawing, the dust-precipitation equipment, is shown as comprising an upstream ionizing element indicated in its entirety by the reference character A, and a dust-precipitating element indicated in its entirety by the reference character B. The ionizing means A and dust-precipitation means B are arranged successively in the direction of gas flow, indicated by the arrows, in a gas duct represented by a wall C.

The ionizing means A comprises a rectangular metallic frame 2 consisting of opposite outer sides 4 and 6 perpendicular to two other opposite outer sides 8 and 10. Additional walls co-operate with the sides 8 and 10 to provide headers 12 and 14, respectively, capable of receiving liquid. The opposite headers 12 and 14 comprise inner walls 16 and 18, respectively, which face each other.

A plurality of alternately relatively insulated and uninsulated electrodes are carried inside the frame 2 for establishing ionizing electrostatic fields through which gas flowing through the frame must pass. The relatively uninsulated electrodes comprise a series of equally spaced hollow elongated open-ended members 20, 22, 24 and 26. The members 22 and 24 are cylindrical tubes, while the members 20 and 26 are semi-cylindrical tubes with their lengthwise edges gas-tightly secured to the walls 4 and 6 of the frame 2. The walls 16 and 18 of the headers 12 and 14 gas-tightly receive the open ends of the various tube members 20, 22, 24 and 26, so that liquid introduced into the delivery or inlet header 12, through an inlet pipe 28, will flow through the tubular members 20, 22, 24 and 26 and into the receiving or outlet header 14 from whence it is conducted by an outlet pipe 30, and thereafter discarded or recirculated, as desired. In Figure 1, it may be observed that the inlet pipe 28 passes through the wall C of the gas-duct, and the pipe 30 may similarly come out of this wall. A pump 32 forces the liquid through a cooling unit 34 which may be a heat-exchanger,

a refrigerating unit or similar device and then into the inlet pipe 28.

A plurality of fine wires 36 are insulatedly supported centrally in each space in the frame 2, between adjacent tubes or tubular members 20, 22, 24 and 26. To this end, a bar 38 may be carried by the sides 4 and 6 of the frame 2 and insulators 40 secured to the bar 38 for insulatedly carrying a bar-structure 42 having arms 44 extending toward the tubular members. The wires 36 may be strung between these arms in a manner known in the art.

Generally, the tubular members 20, 22, 24 and 26 have relatively large curvature with respect to the wires 36 which are relatively fine and insulated with respect to the tubular members. By connecting a suitable voltage between the relatively insulated members and the wires, gas-borne dust particles inside the frame 2 are ionized. Consequently, the wires are recognized as a form of ionising or discharging wires or electrodes and the tubular members as a form of ground, or non-discharging electrodes. Since dust collects on the latter, they may also be called dust-collecting or precipitating electrodes. A simplified circuit for oppositely charging the different electrodes is shown in Figure 4 where the wires 36 are connected to one terminal, preferably the positive terminal, of a source D of high direct-current voltage. The other terminal of this source is connected to tubular members 20, 22, 24 and 26 either directly or through grounded connections which may include the frame 2 and gas-duct wall C.

In general, for air cleaning, the wires 36 should have a diameter of 32 mils. or less, and in practice wire-diameters of from 10 down to 3 mils. are frequently used. For cleaning industrial gases, the wires can be larger. The non-discharging electrodes are usually made from a material which will not deteriorate in the gas being treated. Aluminium and coated iron are satisfactory in the cleaning of ordinary atmospheric air which is not too humid. For more corrosive gases, stainless steels can be used. For air cleaning with comparatively low voltages, for example about 12,000 volts, an outer diameter of 1¼ inches for the non-discharging electrodes is satisfactory when spaced about the same distance from the discharging electrodes.

The dust-precipitating means B comprises a plurality of alternately relatively insulated and uninsulated plates 46 and 48, respectively; the adjacent plates being oppositely electrically charged so as to constitute non-discharging dust-collecting or precipitating electrodes.

Fig. 5 shows a modified form of ionizing means in which headers 50 and 52 are provided having partition walls 54 and 56, respectively, so that water entering through the inlet pipe 58 will pass through two non-discharging electrodes in parallel, before leaving through the outlet pipe 60. Obviously, any kind of tortuous path may be provided for the cooling water traversing the various hollow non-discharging electrodes.

The non-discharging electrodes of Fig. 5 are also provided with scraping members comprising substantially complete rings 62 for the central non-discharging electrodes 64 and half-rings 66 for the end electrodes 68 which are against the walls of the frame. These ring members rest on, or are close to, the surface of the electrodes and can be reciprocated by any suitable reciprocating mechanism which includes connecting rods 70. In Fig. 5, the rods 70 are shown for clarity in the space between the oppositely-charged electrodes, but in practice it is preferred to put them in front or back of the electrodes shown in Fig. 5, that is, rotated 90° from the position shown, so as to be away from the ionized space.

When the precipitating or non-discharging electrodes are cooled sufficiently, back-ionization which would otherwise occur if the electrodes were not cooled, is eliminated.

Fig. 6 shows results obtained in a test with an ionizing means having a thin-walled brass tube of 1¼ inches outer diameter and spaced 1¼ inches from a wire of 3.3 mils. The apparatus was tested with air containing silica dust from gold mines of South Africa, the dust being of a type which produces silicosis. It is known that the total current flowing to the wire is an indication or measure of the back-ionization. The data for Fig. 6 was obtained by passing air having a temperature of 59° C. and a dew point of −5° C. through the ionizing means with a fixed voltage across the positively-charged discharging wire and the non-discharging tube which had a thin layer of dust on it, the layer being 1/16 inch thick or somewhat less. In the test the surface temperature of the non-discharging tube was varied. Three different runs were made with voltages of 10.85 K.V., 11.9 K.V. and 12.9 K.V. across the electrodes. It will be observed that, for all three voltage conditions, the current in microamperes from the wire (ordinates) did not increase until the tube-temperature in degrees Centigrade (abscissæ) exceeded a certain value, depending on the voltage. When the

tube-temperature was raised above this value, the current noticeably increased, indicating a fairly sharp increase in back-ionization. This turning point appears to be the temperature at or below which the tube-surface should be kept, under the particular conditions, for operation without noticeable back-ionization. After back-ionization started, it increased for some time as the tube temperature was increased, but at a more rapid rate at the higher voltages.

Experimentally, it is difficult to ascertain an exact temperature at which back-ionization starts, but the curves indicate that a short temperature range of about 5—10 degrees includes whatever exact point there might be at which back-ionization begins to become noticeable. This point appears to be lowered as the voltage between the electrodes is raised. Thus at 12.9 kilovolts it is about 5° C. and at 10.85 kilovolts it is about 15° C. These values are about 15 to 20 Centigrade degrees above the dew point of the air, but less than the 59° C. temperature of the flowing air-stream.

The dew point of the gas being cleaned also has an important bearing on the maximum allowable temperature-point or the temperature range where noticeable back-ionization begins. Fig. 7 shows results of a test on this variable in the ionizing means used to obtain the curves of Fig. 6.

In Fig. 7, the ordinates are the maximum allowable temperatures in degrees Centigrade as could be best judged, and the abscissæ are the dew points of the test air where the ionizing means was operated with a direct current voltage of 12.9 K.V. across the non-discharging tube electrodes and the discharging wire-electrodes, the latter being positive.

Apparently, the maximum allowable temperature increases almost linearly with increased dew point but tends to level off at the high dew points. This is to be expected because it is known that up to a certain point increased dew point decreases the resistivity of the precipitated dust. The spread between the maximum allowable temperature and the dew point appears to be greater at the higher dew point values.

Size and spacing of the electrodes also effect the temperature to which the tube should at least be cooled for obtaining the most desirable operating conditions. It is believed that anything which increases the discharge from an ionizing electrode lowers the maximum temperature for ideal operation, other things being equal. The thickness of the precipitated dirt layer on the non-discharging tube-electrode also seems to be a factor in back-ionization. Under some conditions, a thin layer seems to give greater back-ionization than a heavier dirt layer. However, a heavier dirt layer decreases cleaning efficiency. The modification shown in Fig. 5 is provided with the scrapers in order to keep the non-discharging tube-electrodes clean, and to limit the thickness of the dirt layer which can be done because the tube-electrodes are kept cool.

In any event, whatever the explanation of back-ionization, or the factors which affect it, keeping the temperature of the non-discharging electrodes below the bend of a curve such as shown in Fig. 6 has the effect of practically eliminating the back-ionization.

Cooling the tubes of an embodiment such as that specifically described may be carried below the dew point of the gas, so that liquid actually condenses on the tubes. The cooling may be carried so far that sufficient condensate forms which runs down the tubes, carrying dirt with it. The result is a self-washing or self-cleaning arrangement. In such a case, it is desirable, as shown in Fig. 8, to slope the lower inner wall 80 of the frame and to provide it with a trough 82 for receiving the dirt-carrying liquid.

Fig. 8 also shows a way of passing cooling water from one ionizing means to another by a short piping connection 84 extending from the outlet header-portion of one unit to an inlet header-portion of the other.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method of electrostatically precipitating dust or the like from a gas by passing the gas successively through an ionising zone and a precipitating zone, wherein the ionizing zone is constituted by an electrostatic field established between spaced discharging and non-discharging electrodes, said non-discharging electrode or electrodes being hollow and cooled to a temperature below that of the gas under treatment, by a cooling fluid passing through said hollow electrode or electrodes and out of contact with the gas under treatment, thereby to prevent or minimise the occurrence of back-ionization.

2. The method as claimed in claim 1, wherein the or each non-discharging electrode is cooled to a temperature below the dew point of the gas under treatment.

3. The method as claimed in claim 1

or 2, including the step of periodically scraping collected dust from the exposed surfaces of the said electrodes.

4. Electrostatic dust precipitation apparatus having an ionizing chamber and a precipitation chamber, said ionizing chamber comprising means for establishing an electrostatic field therein, including spaced discharging and non-discharging electrodes, said non-discharging electrode or electrodes being hollow and cooled to a temperature below that of the gas under treatment, by a cooling fluid passing through said hollow electrode or electrodes and out of contact with the gas under treatment, thereby to prevent or minimise the occurrence of back-ionization.

5. Apparatus as claimed in claim 4, wherein the said field establishing means comprise said plurality of hollow metal electrodes of relatively large surface and a plurality of relatively fine electrodes in spaced discharging relation to said hollow electrodes and including means for causing the flow of said cooling liquid through said hollow electrodes.

6. Apparatus as claimed in claim 4 or 5, including refrigerating means for cooling the cooling liquid prior to its passage through the hollow electrodes.

7. Apparatus as claimed in claim 4, 5 or 6, wherein said plurality of hollow electrodes extends between spaced headers.

8. Apparatus as claimed in any of the preceding claims 4 to 7 inclusive, including scraper means for removing collected dust from the exposed surfaces of said hollow electrodes.

9. Methods of electrostatically precipitating dust or the like from a gas substantially as hereinbefore described with reference to Figs. 6 and 7 of the accompanying drawings.

10. Electrostatic dust precipitation apparatus substantially as hereinbefore described with reference to Figs. 1, 2 and 3 with or without the modifications shown in Fig. 5 or Fig. 8 of the accompanying drawings.

Dated the 9th day of October, 1947.

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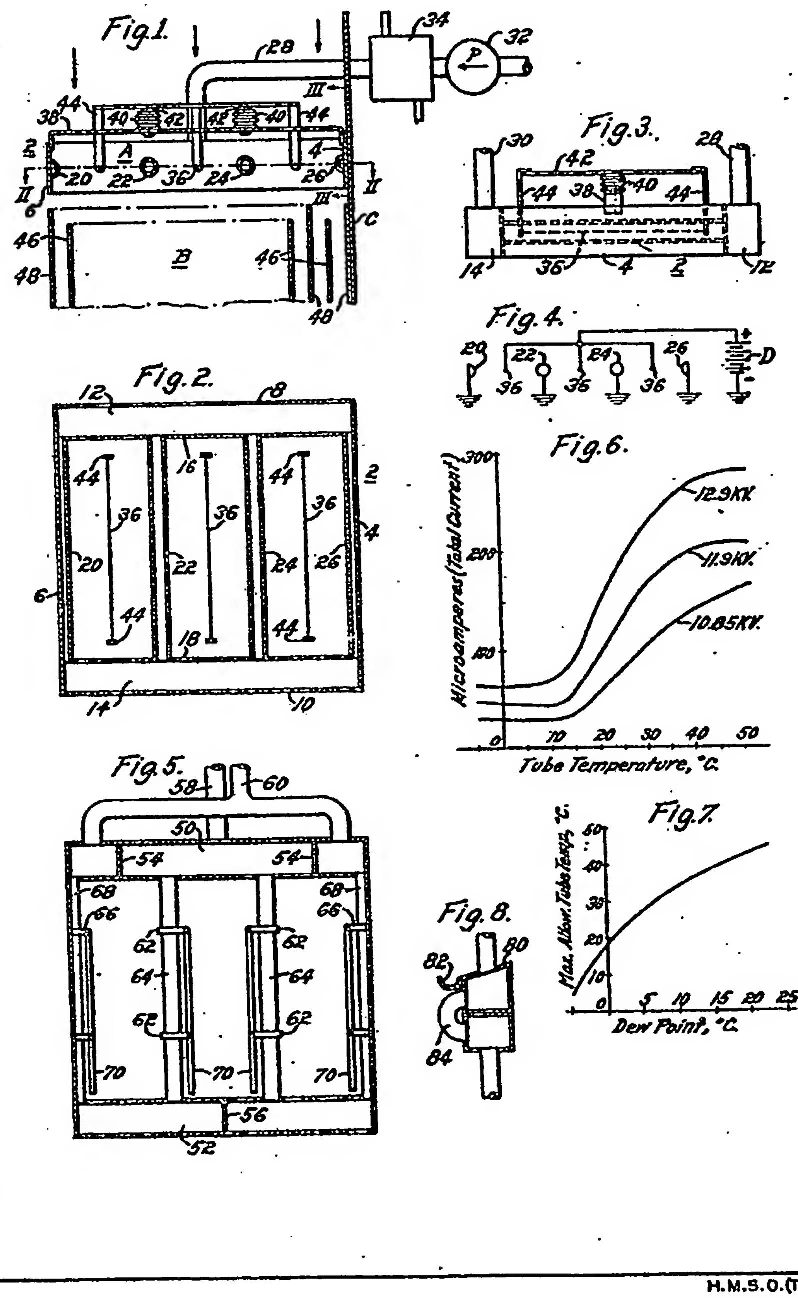
Fig.1.
Fig.2.
Fig.3.
Fig.4.
Fig.5.
Fig.6.
Microamperes (Total Current)
Tube Temperature, °C.
12.9KV.
11.9KV.
10.85KV.
Fig.7.
Max. Allow. Tube Temp. °C.
Dew Point, °C.
Fig.8.